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ABSTRACT

In order for educators to plan for thinking skills in the curriculum, what is meant by thinking must first be determined. Drawing from current research, this report provides working definitions of thinking skills and practical models to explain the working relationships among different levels and different kinds of thought processes. These definitions and models form a three level taxonomy: (1) Cognition--the essential skills (causation, transformations, relationships, classification, and qualification) and their relationships with complex processes (problem solving, decision-making, critical thinking, and creative thinking); (2) Metacognition--the skills of learner awareness of his/her own thinking (monitoring task performance and selecting and understanding the appropriate strategy; and (3) Epistemic Cognition--the skills for understanding the limits of knowing and the nature of problems that can be addressed by the thinker. With an understanding of this taxonomy of thinking, educators can examine the variety of materials and programs for enhancing thinking instruction in the classroom. It is also important to consider the role of subject matter in instruction emphasizing thinking and how student achievement in thinking abilities is to be assessed. (BS)

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THINKING SKILLS: MEANINGS, MODELS, AND MATERIALS

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THINKING SKILLS: MEANINGS, MODELS, AND MATERIALS

Introduction

Of the many tasks that confront educators in planning for thinking skills in the curriculum, few are more critical than determining what is meant by thinking or developing a model of the thinking processes to guide the development of a full educational program.

Currently, there is a great deal of interest in improving student thinking abilities, but there is also a great deal of confusion about what thinking is, what kinds of experiences or programs advance it, and what implications such efforts have for school personnel and policies.

There is no singular glossary of thinking skills. Nor is there an absolute surefire model that comprehensively accounts for the development and description of the ways thinking interrelates with information acquisition, knowledge generation, or systematic reasoning. There are many researchers pursuing the development and instruction of thinking; there are also various programs deliberately designed to teach for thinking enhancement in elementary and secondary schools. This section seeks to provide a glossary of *working definitions* of thinking skills and some *practical models* to help form a taxonomy to explain the working relationships among different levels and different kinds of thought processes. Citations to current research and products are made in the interest of encouraging readers to examine directly the literature and materials available and the various programs currently on the market.

Definitions of Essential Thinking Skills

Thinking is generally assumed to be a *cognitive* process, a mental act by which knowledge is acquired. Although cognition may account for several ways that something may come to be known -- as in perception, reasoning, and intuition -- the current emphasis on thinking skills mainly emphasizes reasoning as a major cognitive focus.

Consider, for example, the following definitions of thinking:

- Thinking is defined as the mental derivation of mental elements (thoughts) from perceptions and the mental manipulation/combination of these thoughts.[1]
- Thinking is the mental manipulation of sensory input to formulate thoughts, reason about, or judge.[2]
- Thinking can be defined as: the extension of evidence in accord with that evidence so as to fill up gaps in the evidence: and this is done by moving through a succession of interconnected steps which may be stated at the time, or left till later to be stated.[3]

There are several interesting aspects underlying these definitions of thinking. Thinking processes are related to other kinds of behavior and require active involvement on the part of the thinker. There are notable products of thinking -- thoughts, knowledge, reasons -- and higher processes, like judging, can also be generated. There are complex relationships developed through thinking, as in the use of evidence over time. These relationships may be interconnected into some kind of an organized structure and may be expressed by the thinker in a variety of ways. If anything, these definitions indicate thinking is a complex and

reflective endeavor, and a creative experience for the individual involved. Such meanings are highly reminiscent of John Dewey's original 1910 writing![4]

Current literature on thinking presents multiple lists of cognitive processes that can be considered thinking skills. There is a danger in confusing one level of thinking with another in terms of its power or significance. Beyer stresses it is important to define skills accurately and suggests reviewing the careful scholarship of researchers like Bloom, Guilford, and Feuerstein in terms of determining useful definitions.[5] If definitions are clearly stated, he maintains, one would not confuse distinctly different processes like inquiry and simple recall. Furthermore, consistent with other researchers of cognitive processes, Beyer distinguishes between lower, essential skills and complex, multiple process-strategies that involve numerous skills. For example, there is a great difference between picking identical examples of a particular insect and finding the antidote to the sting of the same insect. One task involves the basic processes of identification and comparison; the other requires multiple, sophisticated, replicable, and sequenced steps of problem solving.

What are the basic or essential skills of thinking? Nickerson suggests no one taxonomy exists.[6] Educators would be wise, he advises, to select abilities that represent what they want students to be able to do and incorporate these particular skills into their curricula and school programs. Researchers' lists, some relatively old as educational literature goes, can be the basis of such selections. Consider, for example, the categories of

skills suggested by Bloom et al[7] and Guilford[8] over twenty-five years ago:

Bloom's Taxonomy	Guilford's Structure of Intellect
Knowledge	Units
Comprehension	Classes
Application	Relations
Analysis	Systems
Synthesis	Transformations
Evaluation	Implications

Each of Bloom's cognitive categories includes a list of a variety of thinking skills. They are expressed as active verbs to indicate the kind of behavior students are to perform as the objectives or goals of specific learning tasks. For example.

Knowledge: define, recognize, recall, identify, label, understand, examine, show, collect.

Comprehension: translate, interpret, explain, describe, summarize, extrapolate.

Application: apply, solve, experiment, show, predict.

Analysis: connect, relate, differentiate, classify, arrange, check, group, distinguish, organize, categorize, detect, compare, infer.

Synthesis: produce, propose, design, plan, combine, formulate, compose, hypothesize, construct.

Evaluate: appraise, judge, criticize, decide.

Some of these tasks are also evident in Guilford's six categories: recognizing a particular object is a "units" skill, showing a group of similarly colored objects is an "application" task, forming a geometric structure out of six match sticks is a "systems" task similar to Bloom's synthesis. In both researchers' work, there are some unstated dimensions to the thinking skills sequence. Tasks generally move from simpler to complex operations, from more observable and concrete to abstract dimensions, and from an emphasis on working with known materials toward

creating or inventing new, previously unknown approaches or materials. Guilford is interested in both convergent and divergent operations and his ultimate goal is a thorough exposition of the nature of intelligence.

In the years since the initial work of Bloom and Guilford, a greater concern for the developmental appropriateness of tasks or thinking skills has emerged. Hudgin's study of thinking and learning emphasizes Piaget's research on the development of thinking processes as the child grows intellectually.[9] There is an assumption in this research that there is a regular sequence to children's cognitive development, but not precisely in direct age-correlates. When youngsters enter school they are mostly "preoperational" or dominated by their perceptions, suggests the great Swiss epistemologist.[10] Gradually they develop systematic explanations or "concrete" rules for resolving conflicting situations or explaining diverse phenomena; conceptualizations are formed. By the early teens, most students develop abilities to vary interpretations or descriptions in abstract form and to construct "formal" explanations of cause and effect. Higher forms of cognitive operations are developed. Somehow, says Hudgins, the scope of thinking skills expressed in a K-12 curriculum needs to relate to this developmental and cumulative sequence, as well as to the empirical research that it represents. The relationships of particular subject matter to the specific skills to be learned may also be of developmental consequence.

Another issue regarding essential thinking skills is the concern for various modes of thinking that are available to the learner. Different types of symbol systems pertain to this concern. Much school learning

involves linguistic or verbal abilities as well as quantitative, numerical reasoning. Spatial or visual depictions of mental processing currently seem to be becoming more significant to instruction, especially with the advent of video technologies in the classroom environment. How do these different modalities or modes of thinking influence cognitive development? That is an open research question still to be answered. But the testing of cognitive abilities already reflects the appreciation of multiple modes of thinking to the instructional process and the learning of essential thinking skills. The Developing Cognitive Abilities Test is designed around a content format that uses Bloom's Taxonomy and a three-mode organization of content -- verbal, quantitative, and spatial -- for grade 3-12 subjects.[11]

Ideally, then, there are a host of candidates for a basic or essential thinking skills taxonomy. In planning a curricular sequence, it would be wise to be concerned with the developmental level of the learners, the mode of presenting the classroom information, and the subject matters ultimately to be related to. At least five categories of thinking skills merit consideration. Drawing from Bloom and Guilford's work, the following model is suggested as a basic framework for a first-order, operational taxonomy; the definitions of the categories of essential skills emphasized are noted.

- CAUSATION - establishing cause and effect, assessment

  Predictions
  Inferences
  Judgments
  Evaluations

- TRANSFORMATIONS - relating known to unknown characteristics, creating meanings

  Analogies
  Metaphors
  Logical inductions

- RELATIONSHIPS - detecting regular operations

  Parts and Wholes, Patterns
  Analysis and Synthesis
  Sequences and Order
  Logical deductions

- CLASSIFICATION - determining common qualities

  Similarities and Differences
  Grouping and Sorting; Comparisons
  Either/or distinctions

- QUALIFICIATION - finding unique characteristics

  Units or basic identity
  Definitions, facts
  Problem/task recognition

FIGURE 1:

A MODEL OF THINKING SKILLS:
BASIC PROCESSES

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Complex Thinking Processes

If the five categories suggested suffice as the essential thinking skills, what are the more complex processes that are also concerns of thinking skills programs? These are the "macro-process-strategies" that are based on the essential skills, but use them to a particular purpose. Cohen distinguishes processes that rely on external stimuli and seek to be productive, such as making judgments or problem resolution, from processes that depend about equally on external and internal stimuli and seek to be creative.[12] He suggests, then, at least four different complex thinking processes:

- Problem Solving - using basic thinking processes to resolve a known or defined difficulty; assemble facts about the difficulty and determine additional information needed; infer or suggest alternate solutions and test them for appropriateness; potentially reduce to simpler levels of explanation and eliminate discrepancies; provide solution checks for generalizable value.

- Decision Making - using basic thinking processes to choose a best response among several options; assemble information needed in a topic area; compare advantages/disadvantages of alternative approaches; determine what additional information is required; judge the most effective response and be able to justify it.

- Critical Thinking - using basic thinking processes to analyze arguments and generate insight into particular meanings and interpretations; to develop cohesive, logical reasoning patterns and understand assumptions and biases underlying particular positions; to attain a credible, concise, and convincing style of presentation.

- Creative Thinking - using basic thinking processes to develop or invent novel, aesthetic, constructive ideas or products, related to percepts as well as concepts, and stressing the intuitive aspects of thinking as much as the rational. Emphasis is placed on using known information or material to generate the possible, as well as to elaborate on the thinker's original perspective.

These complex processes obviously draw on the underlying essential skills and elaborate upon them. Certain of the essential skills may be more significant to one complex process than others, but current research has not clarified a discrete understanding of such relationships. What seems most important is that young learners develop competence in the essential skills during the early years of schooling, and then -- in middle or junior high school -- begin to be introduced to the more complex processes in specific content matter that is fairly closely related to the use of such skills.

One of the potential observations to be made about learning higher order skills or complex thinking processes is that late middle school or early junior high school is a most appropriate time for such instruction. The growing cognitive capacities of the adolescent learner offer ripe opportunities for the challenge of more complex thinking. Recent research on adolescent development attests to this occurence.[13] Elementary youngsters can benefit from early exposure to varied thinking processes and to different media of presentation, but probably can only approach more complex sequences as they gain experience and as they apply similar skills in multiple content areas. Beyer suggests an effective thinking skills curriculum will introduce only a limited number of skills at a particular

grade level, teach these across all appropriate content areas, and vary the media and contents of presentation.[14] Subsequent grades should enlarge the thinking skills base and provide additional and more elaborate applications of skills already introduced.

It also may be possible that some of the complex thinking processes are more relevant to certain subject areas than to others. For example, Problem Solving thinking skills seem ideal for mathematics or science instruction. Decision Making may be useful for social studies and vocational studies; Critical Thinking may be relevant for the debate team or the language arts class, as well as for the Problems of Democracy or American government course. Creative Thinking might enhance all subjects, as well as be particularly meaningful to the art, music, or literature programs. The point to be made is that the goals of the specific complex process and the objectives for learning in the particular subject area should be parallel and reinforcing.

A suggested model of complex thinking processes is presented in Figure 2. The relationship of any one process to the underlying essential skills is tentatively drawn and is relative to the skills presented in Figure 1. If there are other potential complex processes to consider, one might examine how these compare to the four strategies presented in terms of underlying characteristics and ultimate outcomes.

HIGHER ORDER SKILL	PROBLEM SOLVING	DECISION MAKING	CRITICAL THINKING	CREATIVE THINKING
TASK	Resolve a known difficulty	Choose a best alternative	Understand particular meanings	Create novel or aesthetic ideas/products
ESSENTIAL SKILLS EMPHASIZED	Transformations Causation	Classifications Relationships	Relationships Transformations Causation	Qualificiation Relationships Transformations
YIELDS	Solution Generalisation (potentially)	Response	Sound reasons, proof, theory	New meanings, pleasing products

FIGURE 2:

A MODEL OF THINKING SKILLS: COMPLEX PROCESSES

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Metacognition and Thinking

A useful taxonomy of thinking today must somehow account for metacognitive aspects of the current thinking skills "movement." "'Metacognition' refers to one's knowledge concerning one's own cognitive processes and products."[15] The chief idea involved in metacognition is that learners must actively monitor their use of thinking processes and regulate them according to the objectives of their cognition. Henle considers such regulation the essence of autonomous self-education.[16] Costa suggests that this ability to "know what we know and what we don't know" is a uniquely human trait, but not necessarily one that all adults acquire. He proposes metacognitive skills as a key attribute of formal thinking or higher process skills instruction.[17] He also stresses that the teacher's classroom methodology must constructively deal with metacognition. Other writers maintain metacognitive skills are also significant factors in developing subject-skilled performers.

One of the most salient characteristics of metacognition is that it involves growing consciousness or awareness. One can become more aware of the thinking processes themselves and their specific procedures, as well as more conscious of oneself as a thinker and performer. Learners can acquire an understanding of what the various thinking processes are, so as better to understand and apply them. Some researchers suggest that is why, initially, thinking skills should be taught directly and in relatively content-free situations.[18]

There are two main dimensions to metacognitive thinking. The first is task-oriented; it has to do with monitoring the actual performance of a

skill. The second dimension is strategic; it relates to information about using a particular skill in a particular circumstance and being aware of getting the most informative feedback from carrying out a particular strategy. Figure 3 elaborates on these dimensions:

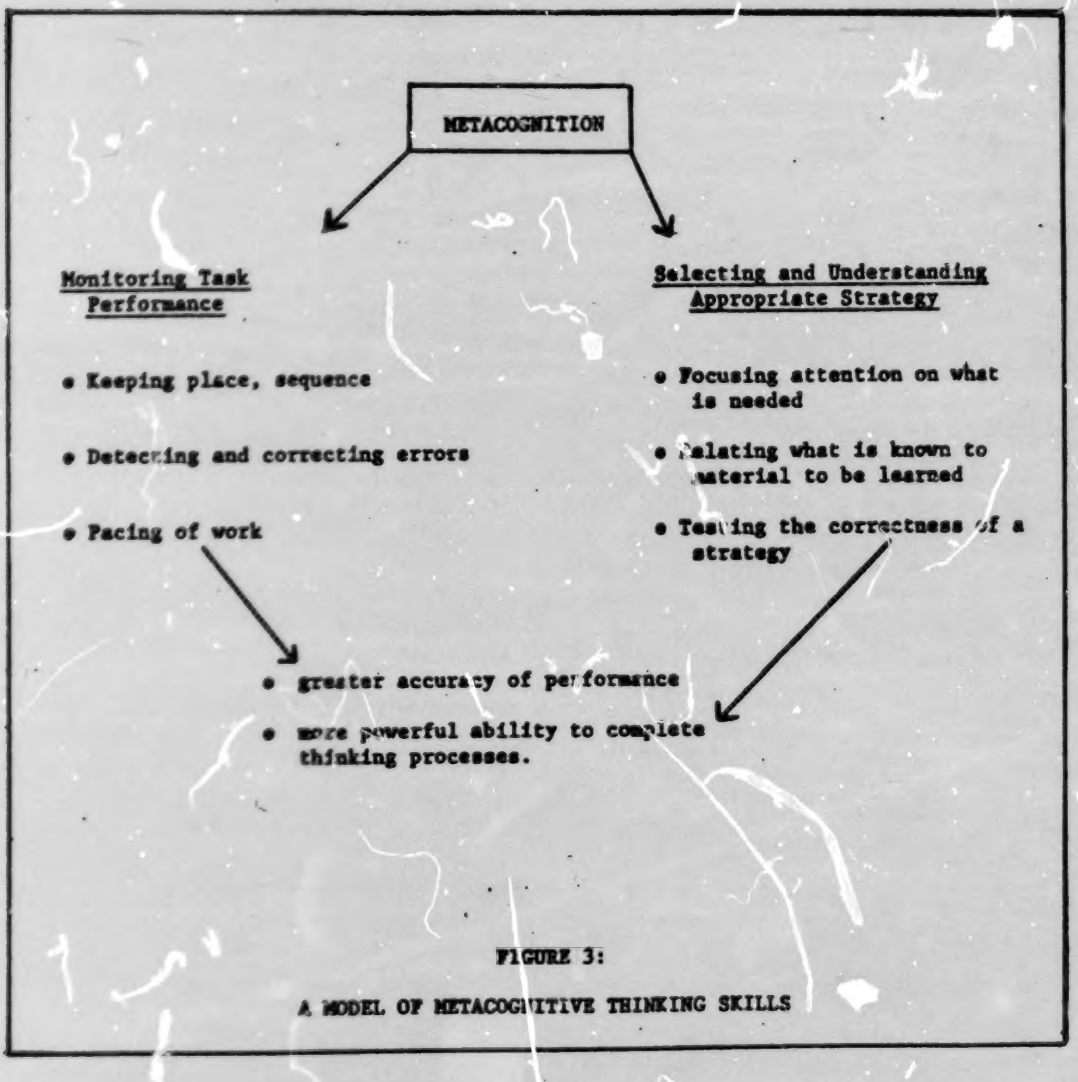
METACOGNITION
Monitoring Task Performance
• Keeping place, sequence
• Detecting and correcting errors
• Pacing of work
Selecting and Understanding Appropriate Strategy
• Focusing attention on what is needed
• Relating what is known to material to be learned
• Testing the correctness of a strategy
• greater accuracy of performance
• more powerful ability to complete thinking processes.

FIGURE 3:

A MODEL OF METACOGNITIVE THINKING SKILLS

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One can see that monitoring task performance involves the learner in watching his/her own activity. Students cannot tell if they are at the right place if they are not aware of the assigned task and the directions for completing it. They might be advised to discriminate sub-goals of a task and relate these to ultimate objectives: in mathematics problems involving reading, for instance, students might identify addition or subtraction as an appropriate operation prior to going on to work through the problem and actually determine a final answer. Detecting errors while working may involve checking or proofreading, re-reading passages or recalculating or retranslating material. Allocating time across work or checking coverage in qualitiative dimensions -- "Have I completed an extensive enough outline?" -- are aspects of pacing the completion of an assignment. The metacognitive thesis is that any and all of these behaviors can enhance the successfulness of the particular task performance. These are also the behaviors often considered in sound study skills programs.

In terms of selecting appropriate strategies to work by, metacognition suggests the first order of learning is to recognize the particular problem and know what information is needed to resolve it and where to obtain such information. Through such consideration, the student comes to recognize the limitations of the learning and the ultimate boundaries of the solution being sought. Sternberg considers these the "executive processes" of sound reasoning.[19] Flavell refers to the various aspects of information retrieval in learning to think -- remember, moniter, and update information -- and draws parallels between classroom learning with experiences involving thinking in the world outside school.[20] Henle suggests that

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recognizing what is understood and to what degree ultimately helps the learner come to terms with the power of his/her own thoughts.[21] Consider, for example, how important it is to know the difference between a wild guess, an informed guess, an hypothesis, an intuition, and a statement of fact. Finally, testing the correctness of a strategy provides the thinker with the opportunity to apply varying sets of evaluative criteria and to determine if, in fact, the right approach is being employed. It presents the learner with the explicit chance to assess the initial selection of strategy, as well as to develop insight into a potentially better choice. More holistic understanding of strategy and the development of fluency or competence in a particular strategy are involved in this type of learning. From the metacognitive viewpoint, the thinker becomes a more autonomous learner as these skills are developed and refined.

Programs and Thinking Skills Materials

This section would not be complete if the cognitive and metacognitive thinking skills discussed are not related somehow to actual programs and specific content materials that are available for teaching thinking. The school practitioner ultimately is concerned with how thinking skills are related to classroom instruction, staff preparation, and to the particular courses that make up the school's curriculum, and all these concerns must relate to available material.

In this area, the first consideration is to realize the variety of materials and programs that currently exist in the expanding area of thinking skills. Some "programs" are only initial plans or basic policies developed by state departments of education or the central office of a

district for infusing thinking skills into the existing curriculum. Some programs are designs for teaching specific, essential processes across existing courses or focusing on one or more complex processes as a main theme of interdisciplinary curriculum development. Finally, some programs are published, packaged products reflecting a considerable investment in materials acquisition and staff development.

Several states have launched thinking skills initiatives through their curriculum development or statewide assessment functions. Vermont, California, Maryland, Pennsylvania, and New Jersey are sponsoring such programs which stress a variety of both essential and complex processes of thinking. The critical thinking emphasis in California extends to higher education as well as to projects in elementary and secondary schools. The statewide assessment testing in Pennsylvania and New Jersey includes sections or items on analysis, reasoning, critical thinking, and problem solving. Many school districts have begun thinking skills projects that reflect their own interests and needs: Pittsburgh developed a program emphasizing the processes of summarizing, classifying, inferring, and evaluating; Baltimore is working on essential process skills cast throughout the curriculum, in large measure based on Bloom's taxonomy; Detroit is part of a national study sponsored by the College Board focusing on the needs of disadvantaged youngsters in mastering Critical Thinking.

Published programs reflect the various emphases that can characterize thinking skills design. Many of these programs are discussed in recent issues of Educational Leadership.[22, 23] Programs like Feuerstein's Instrumental Enrichment focus on the essential processes, in particular to modify the cognitive development of low achieving students. Some programs

focus on one of the complex processes and provide materials for a range of student development in that approach. Lipman's Philosophy for Children stresses critical thinking, while deBono's CoRT materials emphasize creative thinking. Meeker's Structure of Intellect (SOI) Program is organized on Guilford's full model of intelligence and focuses on critical thinking processes. Other programs provide a foundation in the basic processes and then go on to develop one or more of the complex strategies: Bolt, Beranek and Newman's Project Intelligence provides a base in reasoning and then develops units on problem solving, decision making, and inventive thinking. Innovative Science's Strategic Reasoning is built on six essential skills as a foundation for ultimately developing problem solving ability.

A second consideration of great importance to understanding thinking skills materials is the role of subject matter in instruction that emphasizes thinking. Many programs focus on the actual processes of thinking; few have yet articulated the relationship of those processes to the content and methodology of scholarly disciplines taught in the school's curriculum. In a sense, that raises a different cognitive level to be addressed by a thinking skills taxonomy. How do the cognitive and metacognitive aspects of teaching thinking relate to the needs of particular subject matter and the problems, topics, or issues characteristic of that subject matter? Kitchener calls this *epistemic cognition*, how individuals understand the nature of problems and decide what kinds of strategies are appropriate for solving them.[24] To some extent, school personnel confront this problem as they try to locate the appropriate materials for infusing thinking into the existing curricula.

In many cases, teachers may need to develop materials themselves, especially if they try to incorporate thinking consistently across several subject areas. In particular content areas, the questions of scope and sequence of the thinking skills consistent with child development is another practical issue relative to epistemic cognition that requires dialogue among the teachers of that subject. Some published material is available that can be helpful to educators working in particular subject areas, but these resources are few in number. Law in a Free Society is a program in American government that develops critical thinking abilities. Science A Process Approach (SAPA) and the Science Curriculum Improvement Study (SCIS) are two programs dating back to the curriculum development projects of the 1960's that we now can recognize as thinking-based programs oriented to problem solving in scientific inquiry.

A final consideration of finding appropriate materials for teaching thinking is the question of assessment. How do we test youngsters to find out whether, in fact, their essential or complex thinking processes have progressed? This review cannot begin to discuss the intricacies of the Cornell Critical Thinking Test or the New Jersey Test of Reasoning Skills or the Ross Test of Higher Cognitive Processes, but the obvious relationship between what is meant by thinking and what is assessed by thinking skills instruments cannot be ignored. Do we examine only the cognitive abilities or are we concerned with metacognitive and epistemic cognitive progress as well? If so, how do we measure achievement in these areas? How effective are the testing materials provided by the numerous published programs and how relevant are the data developed by such

batteries to other testing programs characteristic of schools? The many issues yet to be resolved are extensive and complex.

In Conclusion

Focusing our attention on what we mean by thinking makes it necessary to consider the various levels of thought that humans are capable of. The complexity of the cognitive process becomes evident. A three-level model has been generated by this examination: *Cognition* - the skills associated with essential and complex processes; *Metacognition* - the skills associated with the learner's awareness of his/her own thinking; and *Epistemic Cognition* - the skills associated with understanding the limits of knowing, as in a particular subject matter, and the nature of problems that can be addressed by the thinker.

Once this "taxonomy" is considered, educators can examine the kinds of material available to them for enhancing thinking instruction in the classroom. They may also become aware that they need to give much more attention to deciding how to relate thinking to the current school program, to teachers' understanding of what thinking is and what that means to student development and classroom instruction, and how to assess student achievement in the various abilities related to thinking.

Without such an understanding of what we mean by thinking, it is unlikely we can even begin to address the extensive problems associated with the development of students' higher cognitive performance.

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